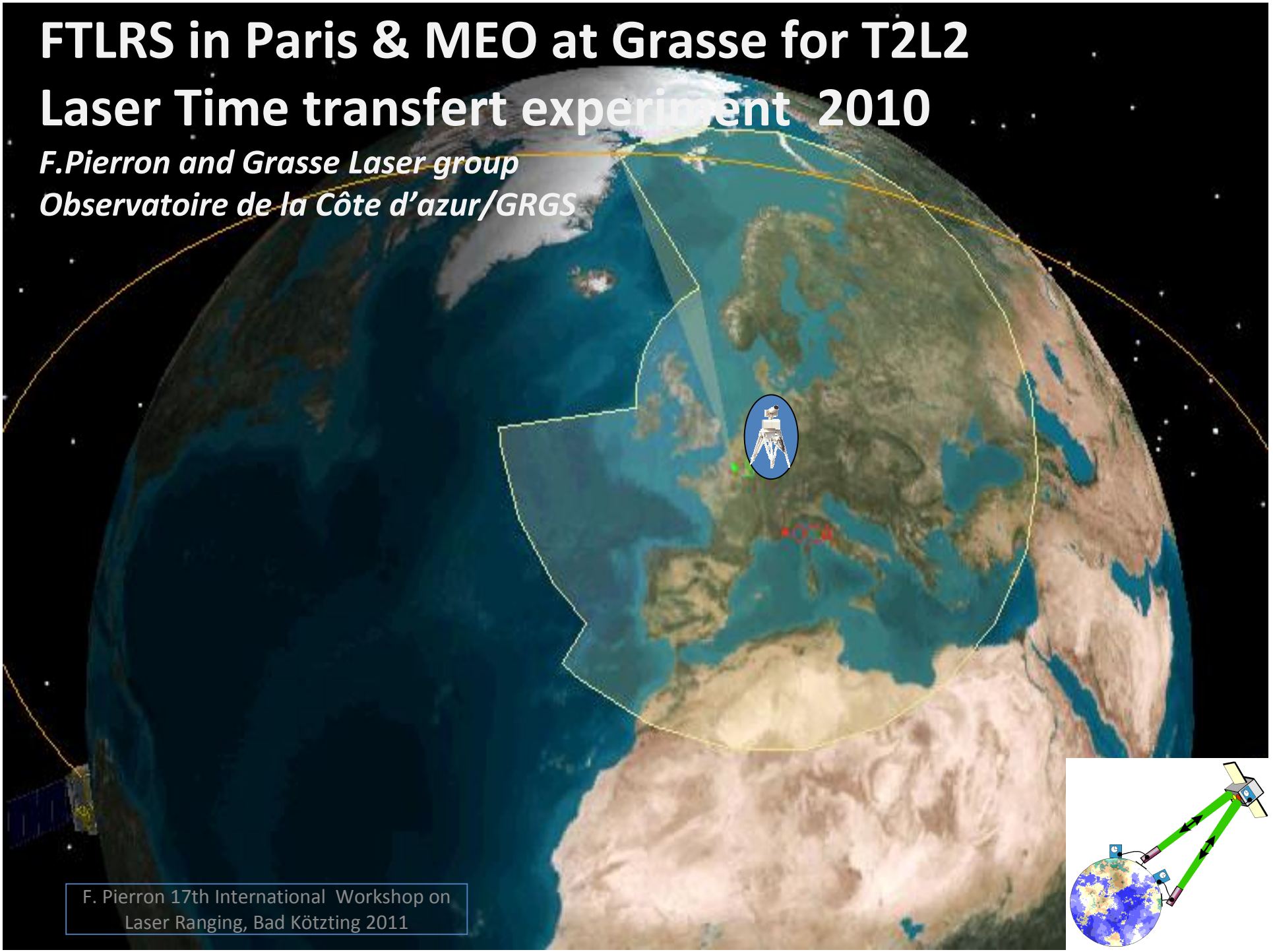
FTLRS in Paris & MEO at Grasse for T2L2 Laser Time transfert experiment 2010

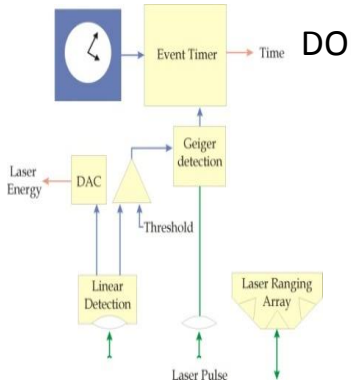
F.Pierron and Grasse Laser group
Observatoire de la Côte d'azur/GRGS



T2L2 Principle
Ground Space time transfer

- T2L2 is a 2 way technique based on the timing of optical pulses emitted (and received) by a laser station and received by a space segment
- Ground : T_{start} T_{return} Space : T_{board}
- From these 3 dates : Difference between the ground and space clock

T2L2 on Jason2

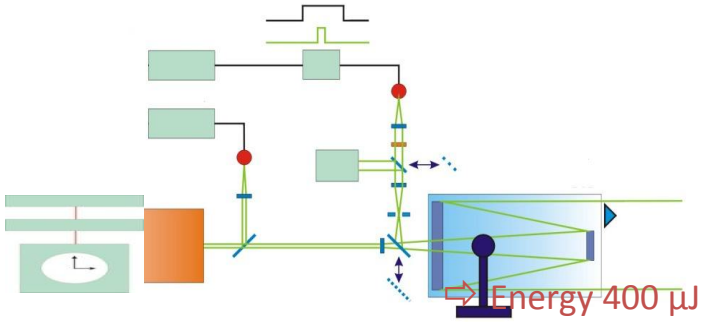


⇨ Masse: 10.4 kg

⇨ Power Consumption: 50 W

⇨ Volume : 20 l

Laser Station



⇨Energy 400 µJ -> 200 mJ

⇨PulseWidth 20 -> 200 ps

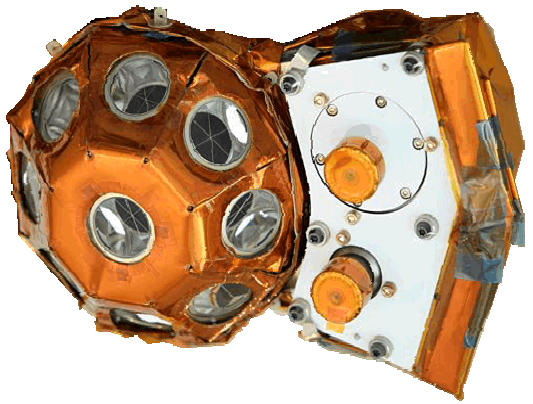
l Comparison between ground to space time transfers coming from the whole laser station network permits to realize ground to ground time transfer

T2L2 Space instrument

- T2L2 was launched in June 2008 on Jason2 (1330 km)

- Electronic module (8.2 kg / 50 W / 280x270x150 mm)
  - Event timer: Repeatability error < 2 ps rms
  - Some parts of the detection
    ⟹ Inside the satellite

- Optical module (2.2 kg / 2 W / 182x143x102 mm)
  - Detection modules: Field of View 110°, λ = 532 nm
  - Corner cube (Jason2)
  - Link to the electronic module by optical fiber
    ⟹ Outside the satellite



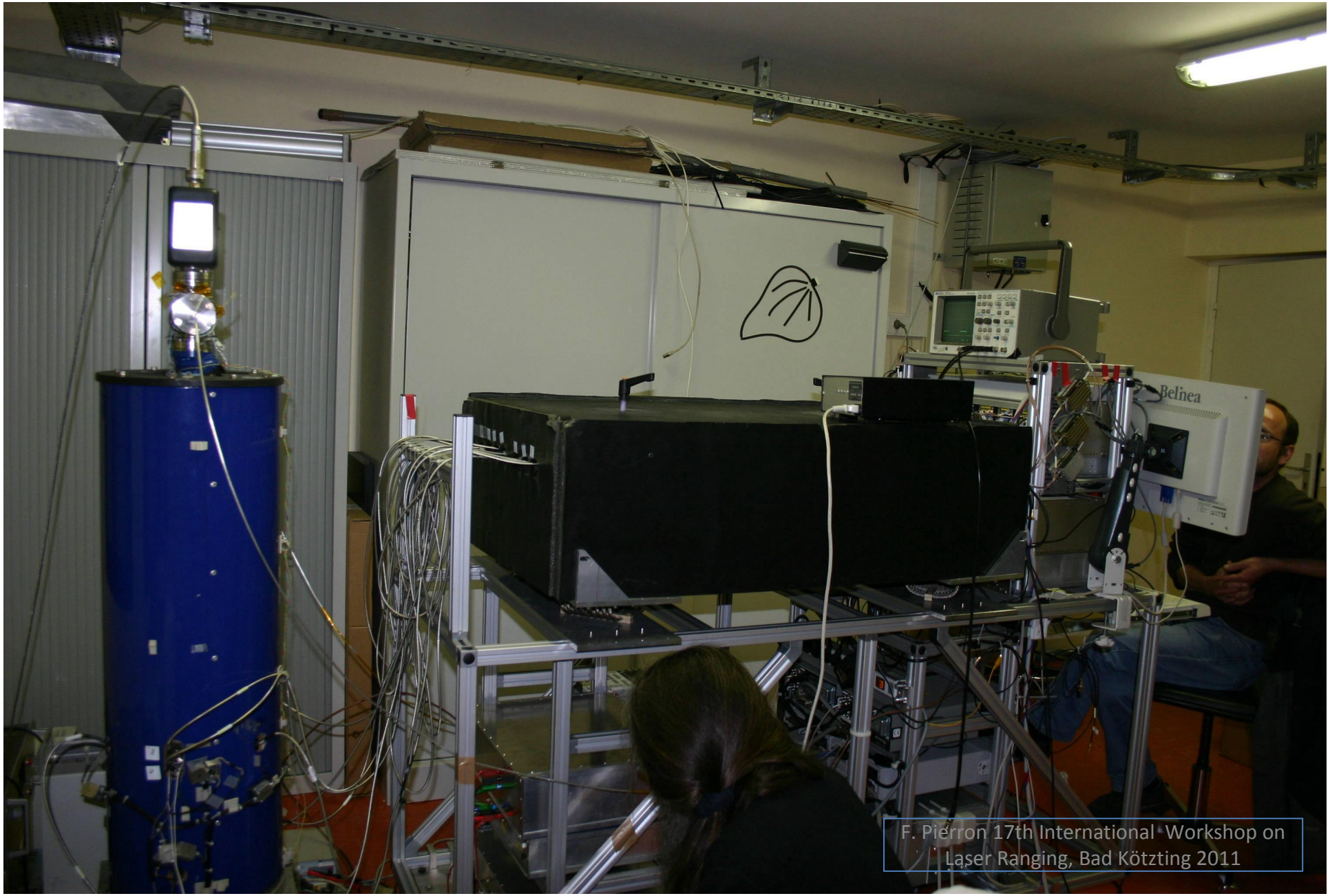
- Up to now the space instrument is nominal
- No evolution nor degradation of performances are observable since the launch

Second T2L2 international campaign
Link: Paris (OP)- Grasse (OCA) in 2010

1. OCA/Grasse
   - » Laser: Meo Station connected to a H-Maser
   - » Clocks: Fountain integrated at OCA in June 2010 ; connected to H-Maser
   - » Microwave Time transfer
     - – TWSTFT (a new Satre modem)
     - – GPS

- Observatoire de Paris
  - – Laser: FTLRS (OCA) integrated in May 2010 (dedicated Platform) ; connected to H-Maser
  - – Clocks: FO + H-Maser
  - – Microwave Time transfer
    - TWSTFT
    - GPS

Transportable Fountain Clock built by Syrte/Observatoire de Paris and installed at Grasse Observatory for T2L2 campaign in 2010



Ftlrs on the « Observatoire de Paris » roofs in 2010 for near « Fountains clocks »

Ftlrs on the « Observatoire de Paris » roofs in 2010 for T2L2 near « Fountains clocks »

Second T2L2 international campaign from June to October 2010

- 1: Perform the best synchronization between ultra stable clocks
  - Atomic fountains
  - H-Masers
  - Cs
- 2: Perform time transfer between GPS – TWSTFT – T2L2

Site	Clock	Time Transfer
Grasse (FRA)	Fountain + HM	GPS – TWSTFT Europe
Paris (FRA)	Fountain + HM	GPS – TWSTFT Europe
Borowiec (POL)	H-Maser	GPS – TWSTFT Europe
Koganei (JPN)	Fountain	GPS – TWSTFT Asia
Simosato (JPN)	Cs/Rb	GPS
Zimmerwald (CHE)	Qx/GPS	GPS
Herstmonceux (GBR)	H-Maser	GPS
Matera (ITA)	Cs + HM	GPS
Wettzell (DEU)	H-Maser	GPS

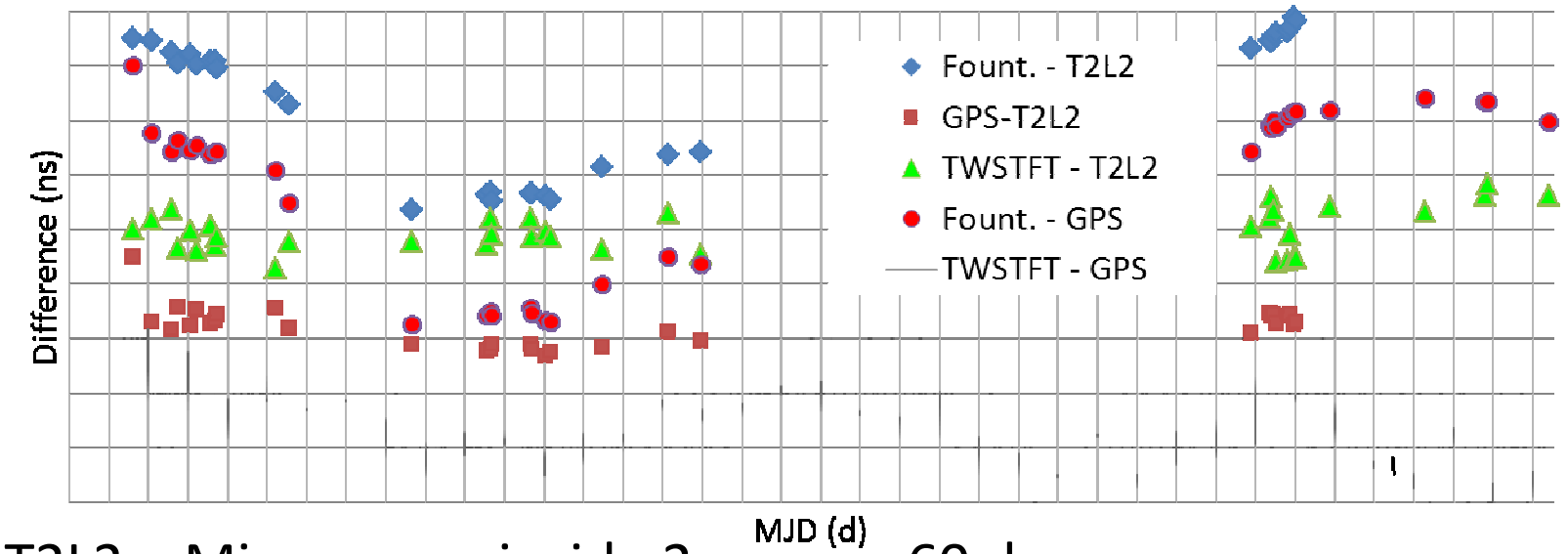
Second T2L2 international campaign Observations

- Observation planning:
  - 4-5 passes per day above each station in common view configuration above Europe or Asia
  - One common orbit between Europe and Asia per day
- Synthesis during activity period: 1155 passes, 650 in common view !

Site	Passes with triplets	Passes with triplets in Common View					
		Paris	Zimmer-wald	Grasse	Matera	Wettzell	Simo-sato
Herstmonceux (GBR)	169	47	14	87	33	19	
Paris / FTLRS (FRA)	140		22	88	43	36	
Zimmerwald (CHE)	85			35	27	21	
Grasse (FRA)	350				77	58	
Matera (ITA)	190					38	
Wettzell (DEU)	167						
Koganei (JPN)	29						5
Simosato (JPN)	25						

Second T2L2international campaign
OP-OCA: Multi-technique comparison

- Time transfer Comparison: T2L2 and GPS and TW
- Atomic Fountain comparison



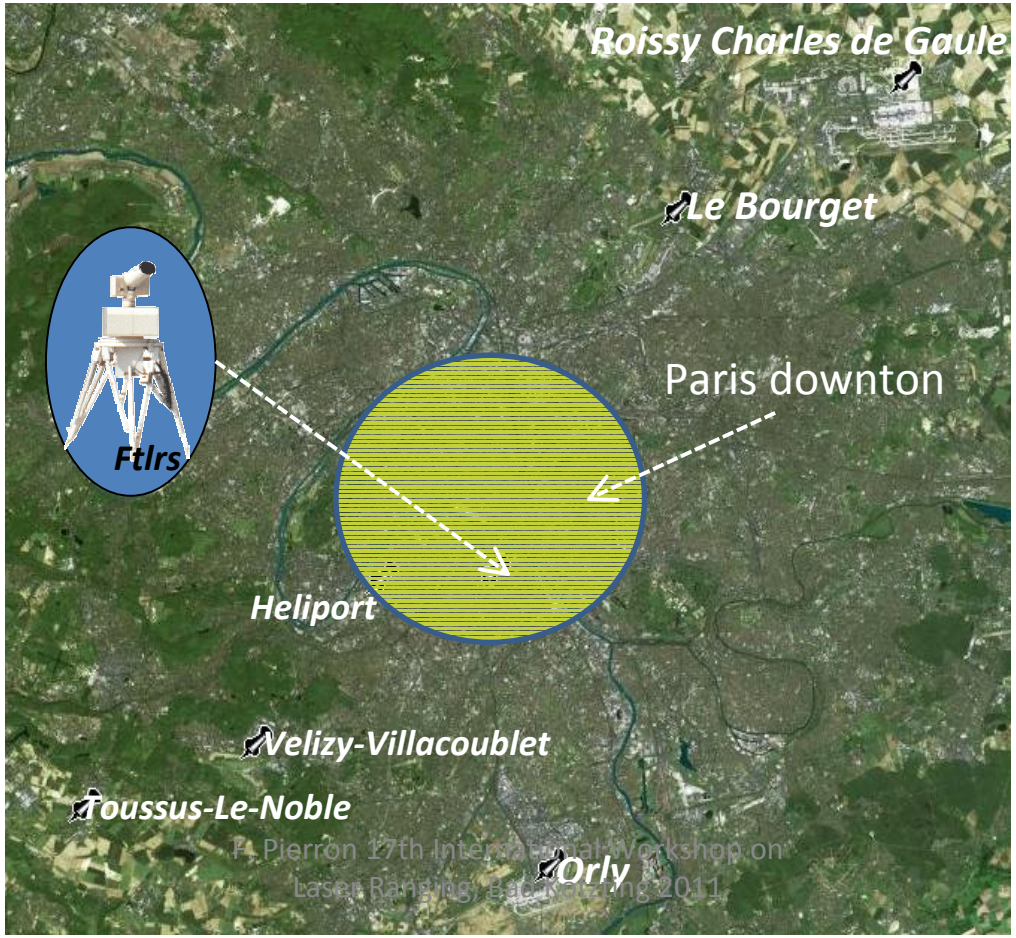
- T2L2 – Microwave: inside 2 ns over 60 days
- Fountains give a frequency information: Phase is integrated

Global T2L2 performance :

better than 100 ps over 1 minute of ranging..

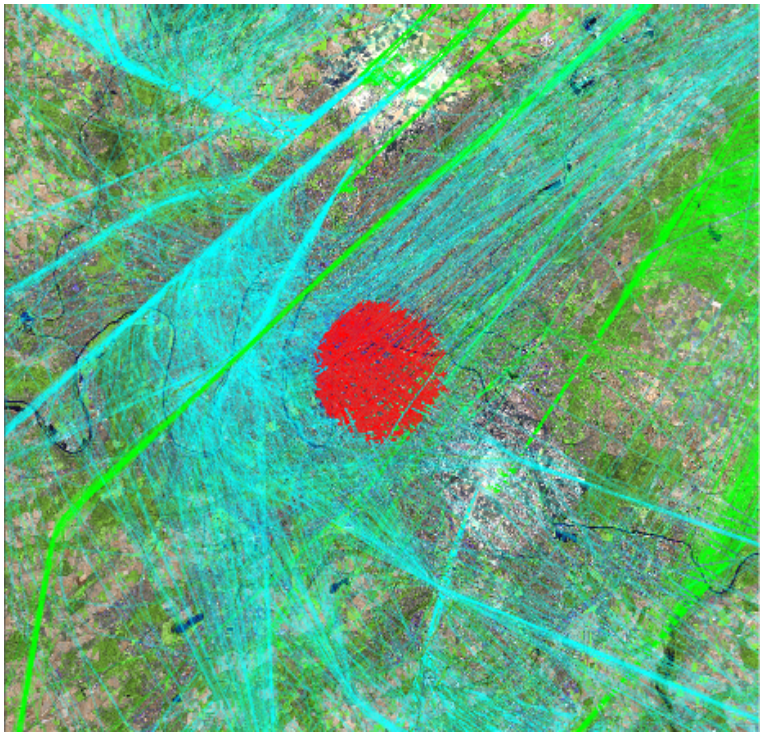
FTLRS at SYRTE / Obs. de Paris

- **The challenge :**
  - An SLR station in the center of Paris, in the middle of air traffic.
  - 5 Airports and 1 heliport

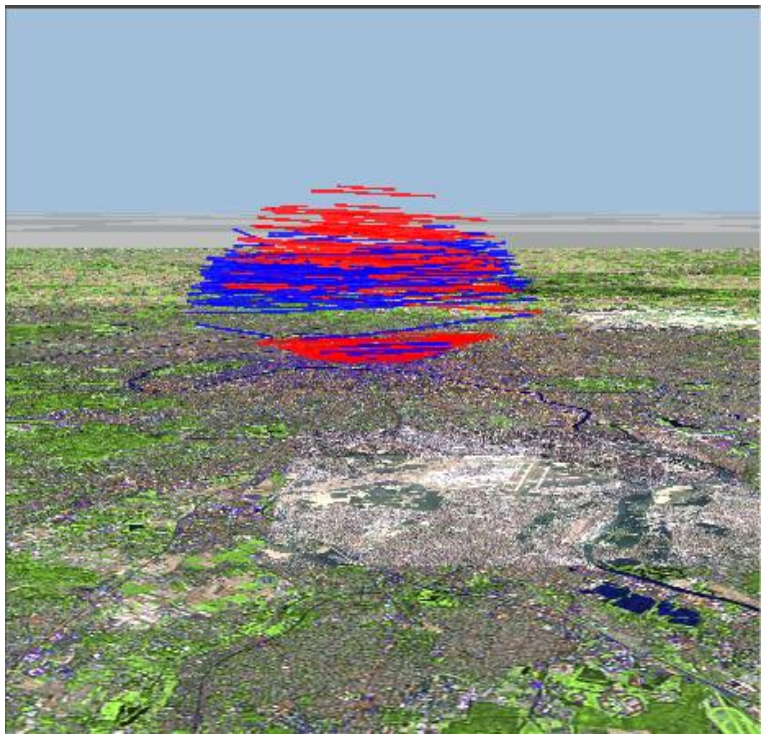


FTLRS at SYRTE / Obs. de Paris

- Preliminary air Traffic analysis with navigation authorities
  - From real air traffic data
  - 2 or 3 planes in the field of view per Jason-2 pass



Air traffic above PARIS, 18/07/2011 : from/to Roissy - Charles De Gaulle, Orly, Le Bourget, Velizy – Villacoublay & Toussus Le Noble (Departure : Bleu ; Arrival : Green ; FTLRS Field of View : Red)



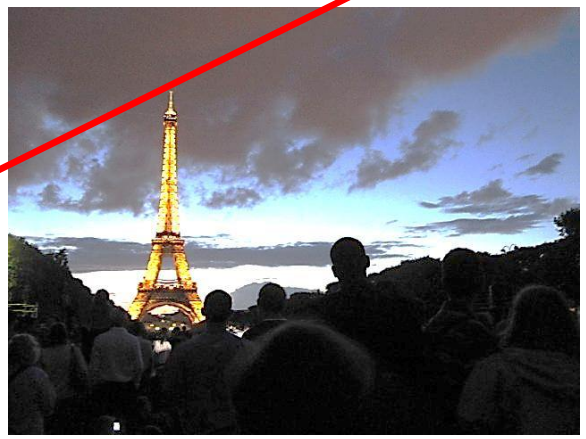
Intersection between Air traffic and FTLRS Field of View

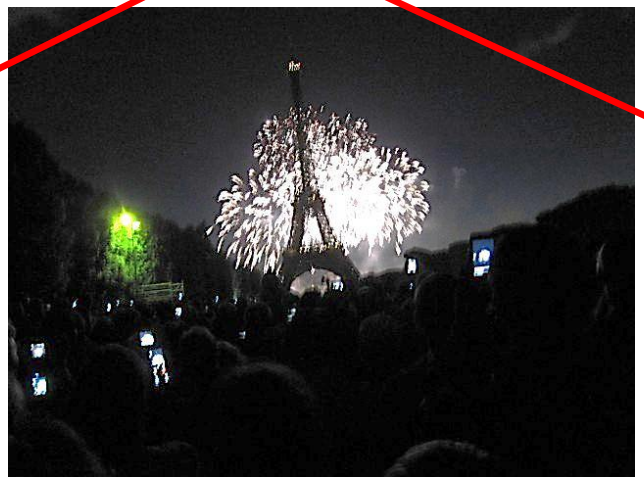
Final aircraft security procedures applied during the campaign for FTLRS in Paris

1.Jason2 complete Schedule (with hours and directions) sent to aircraft navigation authorities one week in advance..

Eventual feed back authorizing or not ranging for every pass day by day

National event on July 14 th in France on "Champs Elysées" at Paris





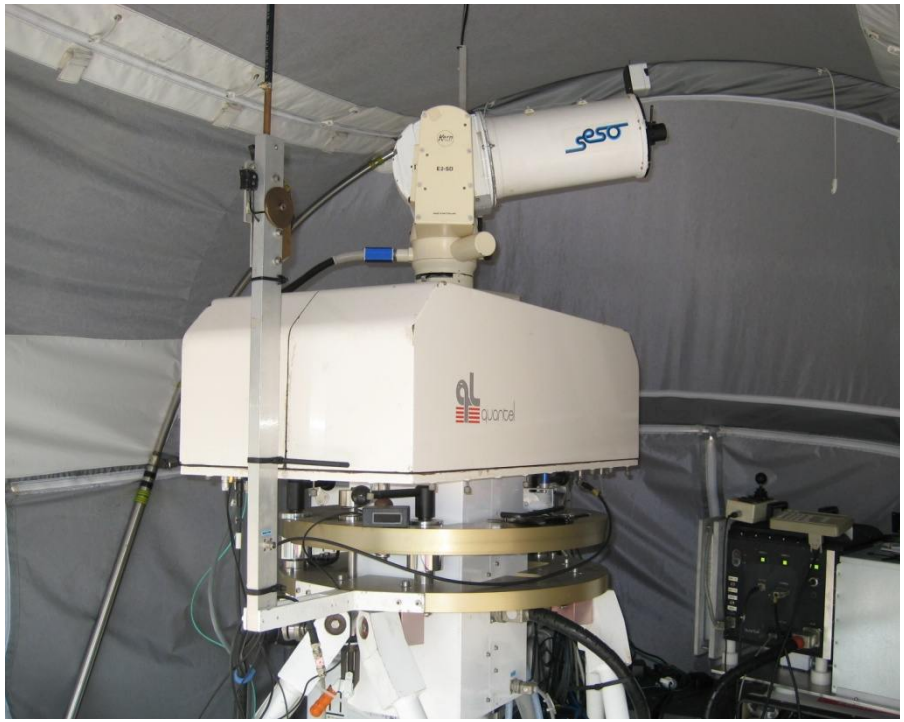
Final aircraft security procedures applied during the campaign for FTLRS in Paris

2.Permanent capability from airport traffic control to phone to the operator in case of late change in trajectory or non schedule flights (military, helicopters,..)

3.Operator outside near the telescope for visual sky watching and alert if needed for daylight and nighttime tracking.

Final aircraft security procedures applied during the campaign for FTLRS in Paris

4.Mini camera fixed on telescope with field of view of some degrees for watching clouds and flight during daylight tracking ..



Final aircraft security procedures applied during the campaign for FTLRS in Paris

5.Transponder receiver giving a plot of aircraft with real time position and way

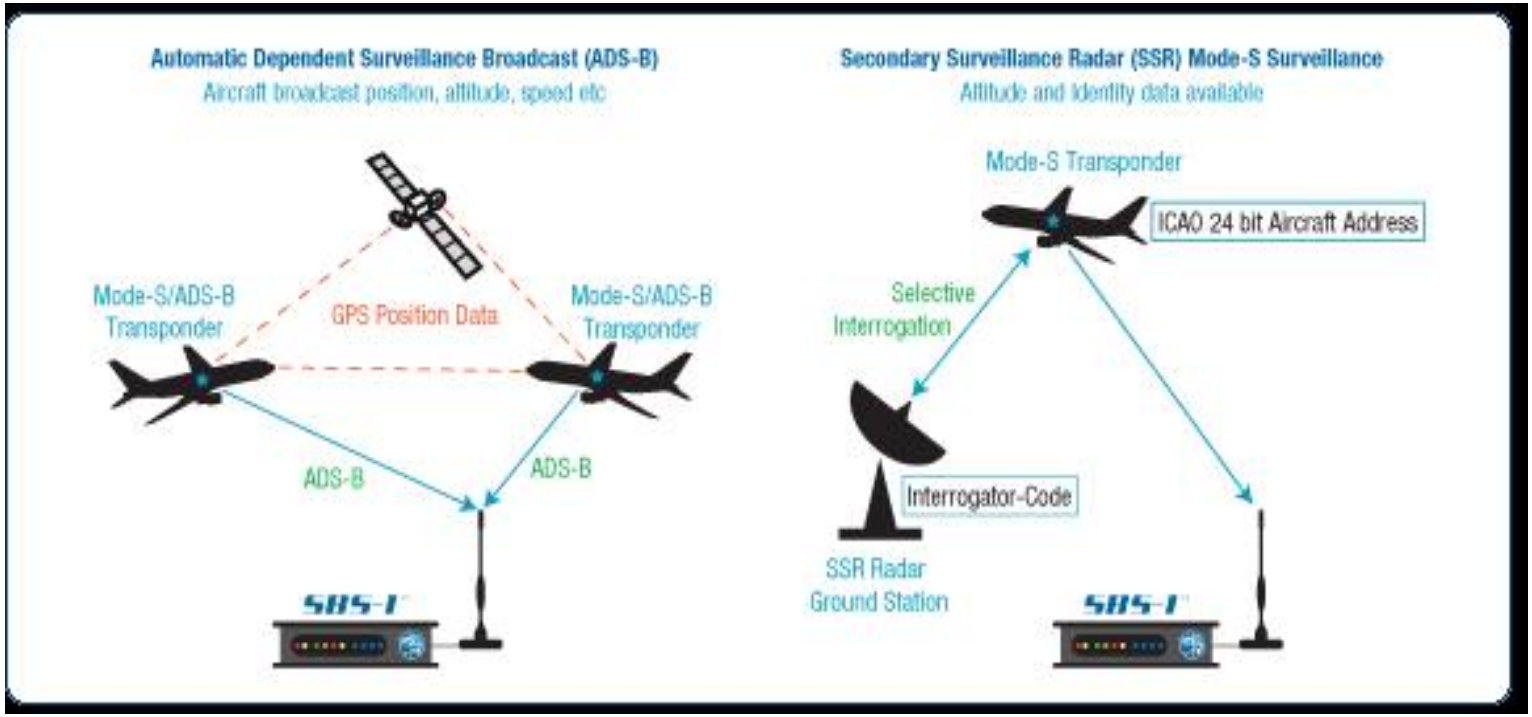
Software associated and easy to tune wit thresholds on :

-distance

-elevation

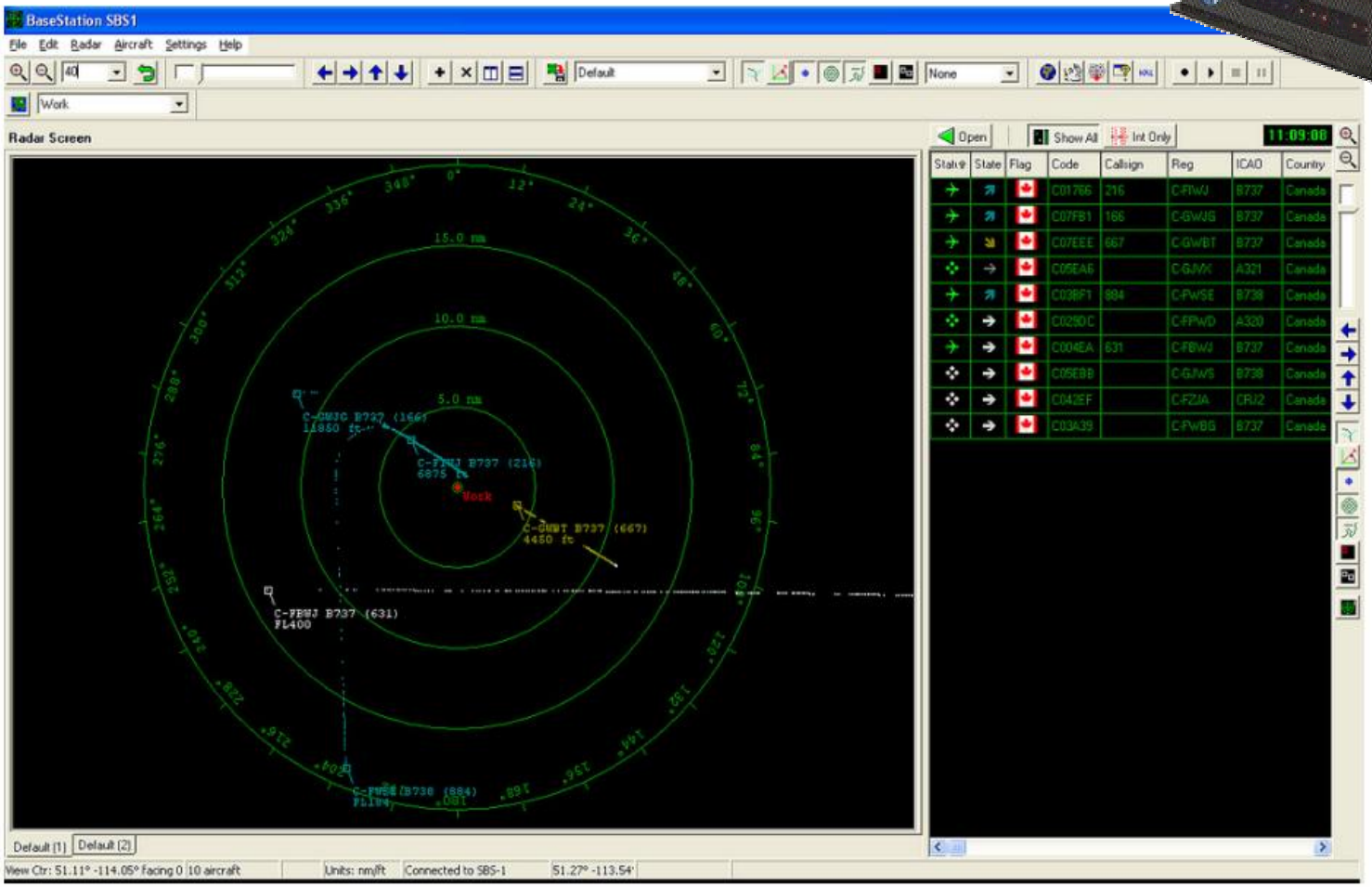
Air Traffic Control for Laser Operation

- Virtual Radar – ADS/B Receiver
  - ADS/B Signal : Position and identifier of the aircraft
  - ADS/B Transponder : Most of commercial aircraft equipped
    (All IFR flight since march 2009 - TBC)
  - Virtual Radar : ADS/B Receiver + Radar like visualization



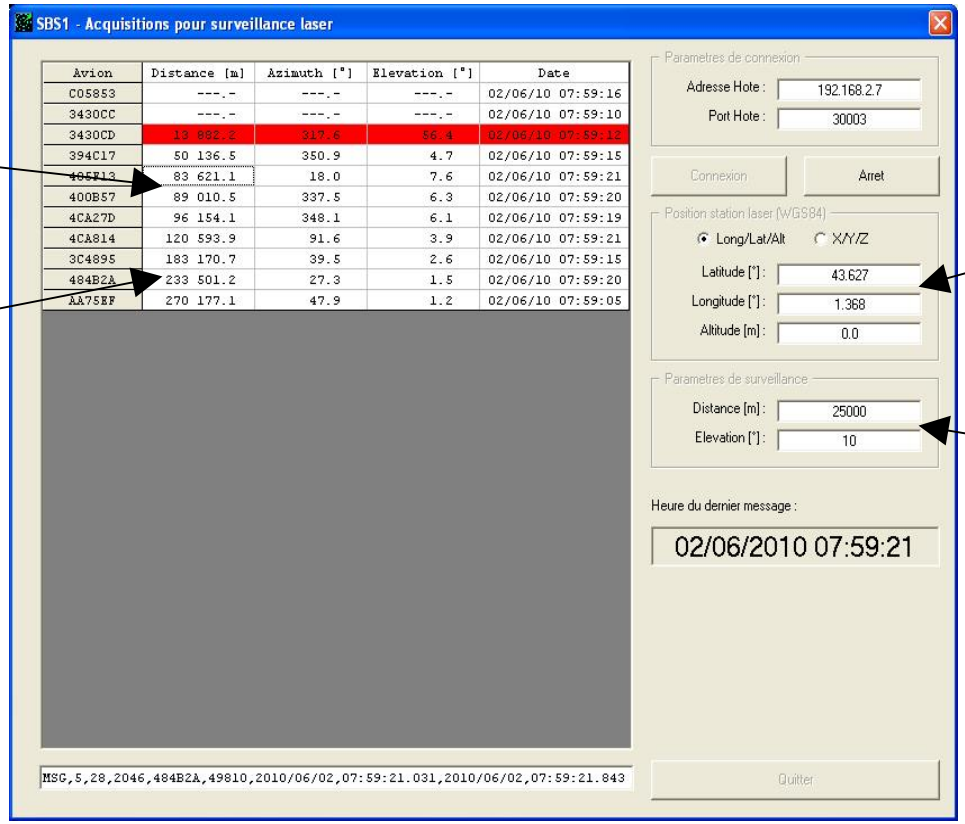
Air Traffic Control for Laser Operation

- **Kinetic Solution :**
  - **SBS-1 ADS/B Receiver**
  - **BaseStation software**



Air Traffic Control for Laser Operation

- **FLTRS add-on**
  - User friendly visualization : Planes in the field of view / critical range



- **Possible improvements : Coupling with laser station / satellite motion**
  - **Critical area ⇔ cone around the laser beam**
  - **Automatic shut down of the laser**

Today, Ftlrs at Tahiti May/August 2011

T2L2 follow-on experiment and colocation with Moblas_8

Thanks for your attention